Reading the high-grade metamorphic record

R. W. WHITE

Institute for Geoscience, University of Mainz, Mainz, Germany (rwhite@uni-mainz.de)

The minerals textures and structures preserved in metamorphic rocks represent an incomplete and encoded record of their evolution during orogenesis. This record, reflecting the pressure– temperature–deformation history of the crust and a range of important crustal processes processes, is a primary source of information for unravelling the tectonic evolution of crustal rocks. Shortcomings in our ability to read the record preserved in rocks, in the form of their mineral assemblages and mineral textures, is a limiting factor in understanding these processes. With increasingly sophisticated methods being employed in geochronological studies, the potential for understanding the timescales of metamorphic evolution and the rates at which metamorphic processes operate may be realized. However, our success at this will depend very much on our ability to provide a sophisticated and robust metamorphic framework in which to interpret geochronological data.

Improvements in our understanding of high-grade metamorphism are ongoing, with mineral equilibria modeling emerging as a powerful approach to understanding the evolution of metamorphic rocks and metamorphic processes. Of key importance is understanding the *P-T* evolution of rocks via effectively reading the mineral assemblages and reaction textures, as well as being able to understand open system processes such as melt loss.

Applying mineral equilibria modeling in geologically-realistic chemical systems, as well as newly-developed methods for calculating chemical potential gradients and volumes of equilibration in rocks allow us to better understand the *P-T* evolution and spatial organization of minerals in rocks. Forward modeling methods such as calculated pseudosections allow observations to be interpreted within a predictive framework and likely mineral assemblage evolutions deduced. The interpretation of geochronology within this framework will allow tighter constraints to be placed on rates of metamorphic evolution.

Are ‘constant’ trace element ratios in oceanic basalts really constant?

WILLIAM M. WHITE

Dept. of Earth & Atmospheric Sciences, Cornell University, Ithaca, NY 14853 USA (wmw4@cornell.edu)

Pb/Ce and Nb/U ratios differ dramatically between the continental crust and the mantle. Furthermore, these ratios appear to be approximately uniform in mid-ocean ridge (MORB) and oceanic island (OIB) basalts. Nb/Ta and Zr/Hf ratios are expected to be nearly constant in both crust and mantle because of the highly similar behavior of the elements involved. This study re-examined question of how constant these ratios are using data from the GEOROC and PetDB databases as well as recent data from the literature. In particular, the study addressed the question of whether statistically significant differences existed between OIB and MORB generally, and among oceanic island chains. Data from GEOROC and PetDB were first filtered to exclude differentiated lavas, samples that were significantly weathered, and poor quality analyses. After filtering, roughly 200 MORB and 1500-2000 OIB values remained, depending on the ratio.

Overall, mean values of Pb/Ce, U/Nb, Nb/Ta, and Zr/Hf for MORB and OIB are indeed similar. Because of this, I used a statistical approach, the Student-t test, to determine if real and statistically significant differences existed. This approach reveals that MORB have statistically significant (95% confidence level) lower Zr/Hf and Nb/U ratios than OIB (39.3 vs 41.5 and 44.8 vs 48.5). Differences in Pb/Ce and Nb/Ta were not statistically significant. The Hawaiian volcanoes have mean trace element ratios close to the overall mean for OIB (partly a consequence of the Hawaiian data representing close to half of all OIB data). However, some other island chains do show statistically significant differences in ratios from Hawaii and the OIB mean. The Canaries, Cape Verdes, Easter Is. and St. Helena have the significantly low Pb/Ce (0.026 to 0.029 compared to 0.036 for Hawaii). The Society Is., Samoa, the Mascarene Is., Kerguelen, and Amsterdam all have Pb/Ce greater than the Hawaiian mean. The Canaries, Cape Verdes have high Nb/U (49 to 62, compared to the mean of 48.8 for Hawaii), while the Society Is., St. Helena, the Mascarene Is., and Tristan da Cunha have low values (46.7 to 32.32). Mean Nb/Ta of oceanic island chains range from 13.71 to 17.01 compared to 15.24 for Hawaii and 15.49 for MORB. At the extremes, the variations are statistically signficant. Zr/Hf ratios vary from 38.63 to 43.6, and at the extremes these differences are significant. Variation in Pb/Ce and Nb/U thus allow for some, albeit limited recycling of continental crust into the mantle, specifically into mantle plume sources, Both Zr/Hf and Ta/Nb in oceanic basalts are systematically different from chondritic values, hence this Earth has differentiated with respect to these ratios.